

Fig. 11. Tangential section of leaf of *Avena sativa* cutting a compound sorus of *P. coronata* midway between spore-bed and epidermis: *a*, teleutospores in cross-section; *b*, cells of fibro-vascular bundle; *c*, inter-sorial stroma in cross-section. Section 5μ thick. $\times 350$.

Fig. 12. Teleutospores of *P. rubigo-vera* on *Triticum vulgare* from Ellis' "North American Fungi" No. 1471, showing variations in size and form upon the same host: *a*, *b*, type spores; *c* and *d*, spores bearing short points at apices; *f*, a one-celled spore. $\times 350$.

Fig. 13. Teleutospores of *P. coronata* Cda. on *Avena sativa* from one host: *a* and *b*, type spores; *c*, *e* and *f*, forms often found; *d*, truncated spore; *g*, two mesospores and a teleutospore from corner of sorus. $\times 350$.

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Achenia of *Coreopsis*.

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(WITH PLATE XVI.)

Coreopsis shows as great a variety of achenia as any genus of *Compositæ*, but they are hard to define. They may be flat or somewhat 4-sided, straight or curved, orbicular to linear-oblong in outline, glabrous to pubescent, winged or wingless, with entire or laciniate-toothed margin, apex truncate or emarginate, pappus of two awns (sometimes more) or of teeth or scales, these generally upwardly hispid (often naked), or all these wanting. The genus is not clearly separated from *Bidens*, for while the one is said to have its awns always upwardly hispid, and the other downwardly hispid, several species in each hybridize freely and break down this distinction. While the genus possesses such a range of fruit structures, and by this alone one can not always distinguish species as now defined, it enables natural groups of a few species to be easily formed, and most of these can then be separated by leaf characters. In some cases it seems questionable whether these sub-divisions should be made, for they embrace so many intermediate forms that no line can be clearly drawn between them. No attempt has been made in this paper to combine species, with the belief that Dr. Gray in his *Synoptical Flora* has given the most satisfactory arrangement that can now be made. His lineal order has been followed in

the main, and little variation from his descriptions has been made, except in greater fullness and when new material has brought to light additional characters since the publication five years ago. So far as I am aware, no attempt has been made to illustrate the achenia of *Coreopsis*, and this paper is presented with the hope that it will aid botanists in determining the species of this genus, as we all know that a good drawing is scarcely less helpful than the specimen itself.

I have not gone into the troublesome question of nomenclature, although several changes have been suggested. The achenia vary so much sometimes in the same species, or even in the same head, that a single drawing is not sufficient for proper illustration: for example, figures 3 and 4 are from the same head. Other species are quite constant and can be recognized at a glance.

I have consulted the following herbaria in the preparation of this paper, and am indebted to those having them in charge for kindly putting them at my disposal: Private collection of Mr. Wm. M. Canby; Columbia College collection (Dr. Torrey's plants), sent by Dr. N. L. Britton; Wabash College Collection, sent by Prof. John M. Coulter; and the National Herbarium at the Department of Agriculture, in charge of Dr. George Vasey, who has also been a source of help in other ways.

§ 1. Achenia not villous-ciliate, with no callus on inner face, often papillose-roughened.

* Achenia straight, with fimbriately dissected wings, 2 awns, smooth or slightly papillose-roughened.

C. nudata Nutt. Achenia oblong, 1-1½ lines long, smooth; the dissected wings but half as broad as body; awns mostly prominent. (Fig. 1.)

Dr. Gray, in *Synopt. Fl.*, describes the awns as "two short subulate awns," and Torrey & Gray speak of "awns scarcely exceeding the wing of the achenium," while the recent collections of Chapman and Curtiss, from Apalachicola, Fla. (the original station), have awns prominent and exceeding the wing, often appearing more striking than shown in fig. 1. This species seems more closely related to the two following than to *C. rosea*, which it resembles only in the color of the rays and disk flowers. Thus arranged, we have a group of 3 species differing from every other *Coreopsis* in their peculiarly dissected wings. The drawing is from Curtiss 1484, collected near Jacksonville, Fla.

C. gladiata Walt. and *C. angustifolia* Ait. are two very closely related species, and many intermediate forms are very puzzling. The achenia do not give very reliable characters, for they vary much even in the same head, and have nothing very constant about them. Fig. 2, perhaps, represents a typical achenium of *C. gladiata* as considered by Gray in Synopt. Fl., with its short awns and pectinate fringe. Fig. 3 is a good representation of *C. angustifolia*, with its narrow fimbriate wings and slender setiform awns. Fig. 4 does not look much like the last, but is from the same head near the center. Fig. 5 represents the other extreme, with wing broader than body. The achenia of these species are linear-oblong to obovate-oblong, $1\frac{1}{2}$ -2 lines long, smooth or papillose-roughened. Fig. 2 is from J. D. Smith's collection of 1883, near Columbia, S. C. Figs. 3 and 4 are from Dr. A. P. Garber's S. Fla. collection, distributed as *C. gladiata*. Fig. 5 is from G. McCarthy's collection of the past season, near Augusta, Ga.

C. integrifolia Poir. has been referred to this section, but has never been collected in fruit.

** Achenia incurved, with scarious entire wings, minute awns (except in *C. Leavenworthii*), smooth to tuberculate-roughened.

C. Leavenworthii Torr. & Gray. Achenia oval, 1 line long; wings as broad as body; awns slender, prominent. (Fig. 6.)

Drawing from Curtiss 1480.

C. Atkinsoniana Dougl. Achenia oblong, 1 line long by $\frac{1}{2}$ line wide, smooth; wings very narrow, often a mere margin; pappus of two small teeth, or obsolete. (Fig. 7.)

Drawing from Howell's collection.

C. cardaminefolia Torr. & Gray. Achenia oval to oblong, 1 to $1\frac{1}{2}$ lines long, smooth or slightly papillose; wings almost as broad as body, sometimes almost as narrow as the preceding; pappus wanting or two very small teeth. (Fig. 8.)

Drawing from Wright's New Mexican collection of 1851.

*** Achenia minute (smallest of the genus), more or less incurved, wingless, awnless, smooth or slightly papillose.

C. tinctoria Nutt. Achenia linear to narrowly oblong, a line or less long, thinnish. (Fig. 9.)

The achenia are much like the following, as shown by the figure. Drawing from Wright's collection of 1849.

C. rosea Nutt. Achenia linear-oblong, less than a line long, thinnish, almost straight, slightly ribbed on inner face. (Fig. 10.)

Drawing from Britton's Long Island collection of 1872. I have transferred *C. rosea* so as to follow *C. tinctoria*. Although it has characters which relate it to *C. nuda*, for our purpose it seems best to consider it in this section. The fruit and habit are so similar that it seems unnatural not to consider it as belonging here.

C. Drummondii Torr. & Gray. Achenia oval to obovate, half a line in diameter, thickish, wingless but with a cartilaginous margin. (Fig. 11.)

The achenia are unlike any others of the genus, but curiously enough the species has been much confused in collections. Drawing from Reverchon's collection, distributed as *C. tinctoria*.

§2. Achenia not villous-ciliate, with a large callus generally developed at each end of inner face.

* Wings thin and broad; pappus two small teeth.

C. coronata Hook. Achenia oval, 1 to 2 lines long, smooth or tuberculate; wings from half to as broad as body; pappus two short or prominent teeth. (Figs. 12 and 13.)

Considerable variation is found in the size of the achenia, breadth of wings, and length of pappus. Fig. 12, from Drummond's collection, has the wings narrow, as described by Torrey & Gray; while fig. 13, from Hall's collections, is the more common form.

C. Harveyana Gray I have not seen.

C. grandiflora Nutt., and its two related species *C. lanceolata* L. and *C. pubescens* Ell., can not be separated upon fruit characters with the specimens at hand. Collectors have almost universally neglected to collect them in fruit, and our material has largely been obtained from old collections. Dr. Gray considered that the species were probably confluent, and the nearly identical achenia and similarity of foliage seem to confirm this. Especially is this true of *C. grandiflora* and *C. lanceolata*. *C. pubescens* Ell. in the Syn. Flora is said to have (like *C. lanceolata*) the pappus very small or obsolete (as in fig. 15), but Curtiss 1485 has awns as long as those of *C. grandiflora*. Fig. 14 is *C. grandiflora* from Bigelow's collections in 1853, Fort Smith, Ark. Fig. 15 is *C. pubescens* from McCarthy's collection of 1888.

** Wings narrow, involute and very thick; pappus minute or none.

C. auriculata L. is well marked by its achenia, although it resembles *C. pubescens* very much in its vegetative characters, under which species it was placed by Torrey & Gray. The achenia are very smooth, a line long by half line broad, tuberculate, incurved; wings narrow, involute and thickened, making the achenium boat-shaped. (Fig. 16 *a* and *b*.)

Fig. 16 *a* is the back view of an achenium, and 16 *b* the front view, the inner ring being the thickened involute margin. Drawing from Curtiss's Virginia collection.

§ 3. Achenia oblong, often villous-ciliate, with no callus on inner face, not papillose-roughened.

* Achenia with narrow wings, flat and smooth.

The first five species, belonging to § *Eucoreopsis*, form a closely related group, and though generally easily separated by leaf characters the fruits vary but little. They all have small achenia, which are more or less incurved, with narrow scarious wings and small or obsolete awns.

C. palmata Nutt. Achenia oblong, with narrow wings and obsolete awns. (Fig. 17.)

C. verticillata L. has oblong to obovate-cuneiform achenia with minute awns. (Fig. 18.)

C. delphinifolia Lam. has achenia somewhat broader than the last, from which it can not well be separated upon fruit characters alone. (Fig. 19.)

C. senifolia Michx. is much like the preceding, but the achenia (2 lines long) are not so narrow at base, oblong or elliptical in outline, and awnless. (Fig. 20.)

A specimen collected by Dr. and Mrs. Britton has achenia $2\frac{1}{2}$ lines long and $1\frac{1}{2}$ lines broad. In 1885 the same botanists collected at Black Mt. Station a form which is probably what Elliott described as *C. CEmleri*, but which Dr. Gray, in Synopt. Flora, considered the "abnormal entire-leaved form" of *C. senifolia* var. *stellata*. It does not accord well with the form examined, and seems to approach forms of *C. tripteris*. The achenia are more oval than in *C. senifolia*.

C. tripteris L. Achenia obovate, broader than the preceding, emarginate at apex. (Fig. 21.)

Drawing from Prof. T. C. Porter's collection of 1868.

** Achenia wingless, somewhat angled, often ciliate on margin.

C. latifolia Michx. is as readily distinguished from its related species by fruit characters as vegetative. Achenia (3

to 4 lines long) narrowed each way from above the middle, the base being narrower than the truncate apex, often stronger ribbed on the outer face, giving a triangular shape, quite glabrous; no awn or pappus of any kind. (Fig. 22.)

Specimens of this species are very rare in collections. The only fruiting specimen found, and from which the drawing was made, was collected by Dr. Gray in 1843. Good specimens are very much desired by the Department of Agriculture.

C. aurea Ait. in its typical form is easily distinguished by its fruit characters, but in some of its varieties approaches the next. Achenia short (1 to 2 lines long), broadly cuneate, slightly pubescent; awns two short broad teeth or wanting. (Fig. 23.)

Drawing from Curtiss' Georgia collection of 1875.

In the var. *subintegra*, as shown by Chapman's plant (Columbia Coll. Herb.), the awns are longer, acute and spreading and resemble some forms of *C. trichosperma*. (Fig. 24.)

C. trichosperma Michx. is rather well marked in its fruit characters, although it presents various forms, some approaching *C. aristosa* on the one hand and *C. aurea* on the other. Achenia 2 to 4 lines long, a line or less broad, slightly pubescent or glabrous, ovate-oblong to cuneate-oblong; awns broad at base, terminating in a short acumination, erect or turned inward. (Figs. 25 and 26.)

Short's plant from Kentucky and Hall's from Kansas have narrow achenia, approaching certain forms of the next.

*** Achenia very flat, wingless but with thin margins.

C. aristosa Michx. is not easily defined as it grades almost insensibly into several related species on the one hand and crosses so commonly with various species of *Bidens* on the other. It seems almost impossible to draw any specific or generic lines about it. Achenia very flat, sometimes slightly ribbed on the faces, 3 lines long, oblong to obovate; awns generally quite long, sometimes equalling the achenium and spreading, but in the var. *mutica* obsolete or nearly so. (Figs. 27 and 28.)

Fig. 31 is from J. Q. A. Fitchey's plant, collected in 1859 at St. Louis, Mo., and considered by Dr. Gray as a hybrid from this species and *Bidens chrysanthemoides*. Fig. 32 is from a plant collected in 1873 by Dr. F. Brendel of

Peoria, Ill. It is evidently a hybrid from this species and *Bidens frondosa*. The awns are downwardly barbed, and the marginal hairs upwardly turned, as in *B. frondosa*, while the rays and leaves are those of *C. aristosa*.

C. involucrata Nutt. is said to have achenia with two short acute teeth, but was not seen. It is closely related to the last through its variety. Fig. 33 is probably a hybrid from this species and *Bidens frondosa*, collected by G. H. French in Ill., in 1878.

C. bidentoides Nutt. Achenia linear to narrowly cuneate, 4 to 5 lines long (largest of the genus), with two prominent awns $\frac{1}{2}$ to $\frac{2}{3}$ their length, slightly spreading, and minute awns from the lateral angles. (Fig. 29.)

Dr. Vasey collected near Washington, D. C., Sept. 23, 1888, a peculiar hybrid from this species and *Bidens connata*, which has the awns of both *Coreopsis* and *Bidens*, that is, they are hispid upward or downward or both ways.

C. discoidea Torr. & Gray. Achenia linear-oblong to cuneiform, 2 to 3 lines long; awns more or less prominent, erect or slightly spreading. (Figs. 30 *a* and 30 *b*.)

EXPLANATION OF PLATE XVI.—All drawings $\times 10$. Fig. 1. *C. nudata*. Fig. 2. *C. gladiata*. Figs 3, 4, 5. *C. angustifolia* (the first two from the same head. Fig. 6. *C. Leavenworthii*. Fig. 7. *C. Atkinsonia*. Fig. 8. *C. cardaminefolia*. Fig. 9. *C. tinctoria*. Fig. 10. *C. rosea*. Fig. 11. *C. Drummondii*. Figs. 12, 13. *C. coronata*. Fig. 14. *C. grandiflora*. Fig. 15. *C. pubescens*. Fig. 16*a*, 16*b*. *C. auriculata*. Fig. 17. *C. palmata*. Fig. 18. *C. verticillata*. Fig. 19. *C. delphinifolia*. Fig. 20. *C. senifolia*. Fig. 21. *C. tripteris*. Fig. 22. *C. latifolia*. Fig. 23. *C. aurea*. Fig. 24. *C. aurea*, var. *subintegra*. Figs. 25, 26. *C. trichosperma*. Fig. 27. *C. aristosa*. Fig. 28. *C. aristosa*, var. *mutica*. Fig. 29. *C. bidentoides*. Fig. 30*a*, 30*b*. *C. discoidea* (from same head). Fig. 31. *C. aristosa* \times *Bidens chrysanthemoides*. Fig. 32. *C. aristosa* \times *Bidens frondosa*. Fig. 33. *C. involucrata* \times *Bidens frondosa*. Figs. 11, 14, 15, 16*b* represent the ventral side; all others show the dorsal.

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BRIEFER ARTICLES.

Sensitive stamens in Compositæ.—It is well known that the flowers of several species of Compositæ are sensitive, among the leading of which are the centaureas and thistles. This fact, together with the great similarity of floral structures, has led me to look for movements in other species. Considerable quantities of the flowers to be studied were collected,